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INFANT MORTALITY AMONG MEDICAID NEWBORNS IN FIVE STATES: THE EFFECTS OF PRENATAL WIC PARTICIPATION

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EXECUTIVE SUMMARY

This study is an analysis of the relationship between prenatal participation in the Special Supplemental Food Program for Women, Infants, and Children (WIC) and infant mortality among Medicaid newborns. It is the third report based on analysis conducted for ***The Savings in Medicaid Costs for Newborns and Their Mothers From Prenatal Participation in the WIC Program*** (the WIC-Medicaid study). Based on newborn analysis files, the study includes all Medicaid births in 1987 for Florida, Minnesota, North Carolina, and South Carolina, and all Medicaid births from January through June 1988 in Texas.

Infant mortality is defined as the number of deaths to Medicaid infants under one year of age per 1,000 live Medicaid births. Infant mortality has two components--neonatal mortality and postneonatal mortality. Neonatal mortality refers to death rates of Medicaid infants during the first 28 days after birth, while postneonatal mortality refers to death rates of Medicaid infants between 28 days and one year after birth.

Infant mortality rates of Medicaid newborns varied significantly across the five study states, ranging from 10.4 deaths per 1,000 live births in Florida to 13.3 in Minnesota to 16.2 and 16.6 in North Carolina and South Carolina, respectively. (In Texas, the infant mortality rate for Medicaid newborns was not available, since the infant death data refer only to six months after birth.) Neonatal mortality rates of Medicaid newborns were, on average, between 50 and 60 percent of the annual infant mortality rates and ranged from 5.5 deaths per 1,000 live births in Texas to 9.2 in South Carolina.

In Florida, North Carolina, South Carolina, and Texas, WIC participation by 30 weeks gestation is associated with a significant reduction in infant mortality, with most of the decline attributable to reductions in neonatal mortality.

- ***Infant Mortality.*** With the exception of Minnesota, the predicted infant mortality rates for prenatal WIC participants are roughly one-quarter to two-thirds the predicted infant mortality rates for nonparticipants. The estimated reductions

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in infant mortality rates of Medicaid newborns resulting from prenatal WIC participation are 3.6 infant deaths per 1,000 live births in Florida, 4.0 in Texas (six-month mortality), 8.4 in North Carolina, and 27.2 in South Carolina.

- ***Neonatal Mortality***. The proportionate reductions in neonatal mortality rates attributable to WIC are larger than the proportionate reductions in infant mortality. The predicted neonatal mortality rates for prenatal WIC participants are roughly one-sixth to two-thirds the predicted neonatal mortality rates for nonparticipants. The estimated reductions in neonatal mortality rates of Medicaid newborns resulting from prenatal WIC participation are 2.3 neonatal deaths per 1,000 live births in Florida, 3.0 in Texas, 7.3 in North Carolina, and 19.9 in South Carolina.

- ***Postneonatal Mortality***. With the exception of South Carolina, prenatal WIC participation is generally not associated with postneonatal mortality of Medicaid newborns.

Two parts must be considered when these findings are interpreted. First, the estimated effects of prenatal WIC participation on infant mortality are independent of the effects of prenatal care on infant mortality. Infant mortality of Medicaid newborns is also significantly related to the adequacy of prenatal care. In all five states, receiving inadequate versus either adequate or intermediate levels of prenatal care is associated with a higher likelihood of an infant death. In addition, receiving inadequate prenatal care has a stronger effect on postneonatal mortality than on neonatal mortality.

The second point is that the estimated effects of prenatal WIC participation on infant mortality are not independent of unobserved characteristics that might also influence infant mortality. WIC participants are a self-selected group of women who may choose to participate in the WIC program for underlying reasons that may independently lead to lower infant death rates. For example, some pregnant women may not participate in the WIC program because they lack access to or knowledge of publicly funded programs that provide health care and other services, which may independently affect birth outcomes. Thus, the estimated effects of prenatal WIC participation on infant death rates may overstate the true effects since, relative to nonparticipants, WIC participants would

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have enhanced access to prenatal care and lower infant death rates even in the absence of the WIC program. Conversely, if the WIC program is successful at reaching high-risk, low-income pregnant women, infant death rates of WIC participants may be higher than nonparticipants, and the estimated effects of prenatal WIC participation would understate the true effects. The problem introduced by self-selection may be offset to some extent by the facts that (1) the adequacy of prenatal care is also likely to be related to any such underlying differences between WIC participants and nonparticipants, and (2) the analysis controls for the adequacy of prenatal care in estimating the effects of prenatal WIC participation. However, the potential implications of the self-selection issue should be kept in mind when interpreting the study findings, particularly for South Carolina, where the differences in infant mortality between WIC participants and nonparticipants are very large.

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I. INTRODUCTION

This is the third report based on analyses conducted for *The Savings in Medicaid Costs for Newborns and Their Mothers From Prenatal Participation in the WIC Program* (the WIC-Medicaid study). The first report examined the relationship between prenatal WIC participation, Medicaid costs, and a variety of birth outcomes (Devaney, Bilheimer, and Schore 1991, 1992), and the second examined very low birthweight among Medicaid newborns (Devaney 1992). This third report presents the results of an analysis of the relationship between prenatal WIC participation and infant mortality among Medicaid newborns.

The report is organized in three chapters. The remainder of this chapter provides a brief overview of the WIC-Medicaid study findings and the database used in the study. Chapter II presents some background material on the WIC and Medicaid programs and highlights findings from previous research on infant mortality and its relationship to prenatal WIC participation. Chapter III presents the findings from a descriptive and multivariate analysis of infant mortality among Medicaid beneficiaries.

WIC/MEDICAID STUDY FINDINGS

The WIC-Medicaid study examined the relationship between prenatal WIC participation, Medicaid costs from birth to 60 days after birth, and a variety of birth outcomes. These outcomes included birthweight, gestational age, the incidence of low birthweight, and the incidence of a preterm birth for Medicaid beneficiaries. The study period included all Medicaid births in 1987 for Florida, Minnesota, North Carolina, and South Carolina and all Medicaid births from January through June 1988 in Texas.

The principal findings from the WIC-Medicaid study are the following (Devaney et al. 1990 and 1991):

- Prenatal WIC participation was associated with substantial savings in Medicaid costs during the first 60 days after birth. For newborns and their mothers, the estimated savings in Medicaid costs during the first 60 days after birth associated with prenatal participation in the WIC program ranged from $277 in Minnesota to $598 in North Carolina, with

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intermediate values of $347, $493, and $565 in Florida, Texas, and South Carolina, respectively.

- For newborns only, the estimated savings in Medicaid costs from birth through 60 days were $744 in North Carolina and $573 in Texas.

- The estimated savings in Medicaid costs during the first 60 days after birth related to prenatal WIC participation exceeded the costs of providing prenatal WIC benefits. For every dollar spent on the prenatal WIC program, the associated savings in Medicaid costs during the first 60 days after birth ranged from $1.77 to $3.13 for newborns and mothers and from $2.84 to $3.90 for newborns only.

- In all five study states, prenatal WIC participation by Medicaid beneficiaries was associated with increased birthweight. The average increase in birthweight related to prenatal WIC participation by Medicaid beneficiaries ranged from 51 grams in Minnesota to 73 and 77 grams in Florida and Texas, respectively, to 113 and 117 grams in South Carolina and North Carolina, respectively.

- Prenatal WIC participation by Medicaid beneficiaries was also associated with a lower incidence of low birthweight newborns, longer gestational age, and a lower incidence of preterm birth.

One important birth outcome not examined in the WIC-Medicaid study is infant mortality. Infant mortality (deaths to infants up to one year of age) in the United States remains a major public health policy concern. In 1987, the United States ranked 24th in the world in infant mortality, behind most developed and some developing countries. While U.S. infant mortality rates declined dramatically from the mid 1960's to the early 1980's, the rate of decline slowed during the 1980's, and the infant mortality rate for black infants remains approximately twice the rate for white infants (National Center for Health Statistics, 1990). The WIC-Medicaid database provides an opportunity to examine the incidence of infant mortality among Medicaid newborns and to assess the relationship between infant mortality and prenatal WIC participation. As described below, the number of Medicaid newborn observations is very large (nearly 105,000), data are available on whether and when the newborn died, and

for each newborn, whether the mother participated in the WIC program during pregnancy.

WIC/MEDICAID DATABASE

The database constructed for the WIC-Medicaid study served four major purposes: (1) to identify Medicaid mothers and newborns, (2) to provide information on Medicaid costs from birth to 60 days after birth, (3) to determine whether the mother participated in the WIC program while she was pregnant, and (4) to provide information on birth outcomes and on the use of prenatal care. In each state, the analysis database was constructed from the linkage of three main state data files--the Medicaid paid claims and eligibility files, the WIC program files, and the Vital Records birth and infant death files.

Medicaid eligibility and paid claims files were used to identify Medicaid-covered births and to provide data on Medicaid costs for the analysis. The analysis sample includes all Medicaid-covered births that occurred in 1987 in Florida, Minnesota, North Carolina and South Carolina, and those in the first six months of 1988 in Texas. In Texas, the study is based on all Medicaid births that occurred during the period from January through June 1988, since the data necessary to identify WIC prenatal participants were not available for births in an earlier period.

Data from the states' WIC data systems were used to determine whether a Medicaid-covered mother was receiving WIC benefits while she was pregnant and, if so, the costs of providing the WIC food packages.

Data from the Vital Records birth and infant death files retained for the study include: sex, number, duration of gestation, and birthweight of newborns; whether the newborn died within one year of birth (six months in Texas) and, if so, when; age, race, ethnicity, education, and marital status of mothers; prenatal care adequacy; and number of previous live births and previous pregnancy terminations. The adequacy of prenatal care was measured with a modified Kessner Index (Kessner et al. 1973). The Kessner Index combines information on the timing of entry into prenatal care with the number of visits recorded and the length of pregnancy. For a full-term pregnancy, adequate prenatal care is defined as nine or more visits, with the first visit occurring during the first trimester of pregnancy; inadequate care is defined as four or fewer visits. Intermediate care for a full-term pregnancy encompasses all levels of prenatal care in between the two extremes. Adequate prenatal care for

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preterm births (births of less than 37 weeks gestation) requires a decreasing number of visits as the length of gestation decreases.

To conduct the analysis of the effects of prenatal WIC participation on Medicaid costs and birth outcomes, the data on Medicaid costs, WIC participation, and birth outcomes were combined for each Medicaid-covered birth. Overall, the WIC/Medicaid analysis database includes nearly 105,000 Medicaid births. The proportion of these births occurring to WIC participants varied across the study states, ranging from nearly one-half of the Medicaid births in Texas to almost three-quarters of the Medicaid births in South Carolina.

II. PROGRAM BACKGROUND AND FINDINGS FROM PREVIOUS RESEARCH

In this chapter we provide (a) an overview of the WIC and Medicaid programs, and (b) a discussion of findings from previous research on the effect of prenatal WIC participation on infant mortality.

BACKGROUND ON THE WIC AND MEDICAID PROGRAMS

The Supplemental Feeding Program for Women, Infants, and Children (WIC) was authorized by Congress in 1972 to provide nutritional screening, food assistance, nutritional education, and health and social service referrals for low-income pregnant and postpartum women, their infants, and children up to age five. The major goal of the prenatal component of the WIC program is to improve the nutritional status of low-income pregnant women. Program eligibility depends on both income and evidence of medical or dietary risks. States have the option of setting income eligibility standards between 100 and 185 percent of the poverty level, provided that income eligibility is no lower than that for free or reduced-price health services. Nearly all states have set income eligibility at 185 percent of the poverty level, although, in 1987, a few locations in Texas, Florida, and North Carolina may have used a lower income eligibility criterion. Medical risks include anemia, extremes of leanness or obesity, maternal age, or a poor pregnancy history. Dietary risks are primarily poor dietary patterns.

The WIC program has become an important part of prenatal care provided to low-income pregnant women by public health clinics. Nationwide, the WIC program has grown from a $750 million program that served 2 million women, infants, and children per month in 1980 to a $2.6 billion program that served an estimated 5.3 million women, infants, and children per month in 1992. During fiscal year 1987, the WIC grants in the five study states ranged from a $26 million program that served an average of 56,000 per month in Minnesota to a $112 million program that served 226,000 persons per month in Texas.

The organization of program operations at the local level varies greatly, but for pregnant women it works approximately as follows. When a woman learns about the program and applies at a local WIC office, she is screened to determine whether she meets the income criterion and one

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or more of the risk criteria for eligibility. If she is eligible, she receives a nutrition education session and food instruments for the purchase of a food package from a participating vendor. Usually (though not always), application, eligibility determination, service receipt, and health care referrals all occur in the initial visit. The frequency of food instrument pick-up varies from once every month to once every three months (at which time food instruments for three months are picked up). In subsequent months, the participant will then return to the WIC office periodically in order to pick up her WIC food instrument and receive nutrition education services. Prenatal participants are eligible for WIC benefits through the end of the pregnancy and up to six weeks postpartum.

Authorized under Title XIX of the Social Security Act, Medicaid is a joint federal and state program that reimburses the covered medical-care costs of low-income persons. It is the nation's largest program providing reimbursement for health care services to the poor, but not all low-income persons are eligible. Eligibility depends on categorical status in addition to income, and states have considerable discretion in determining income eligibility ceilings. In the five study states, the income-eligibility ceiling for Medicaid during the study period was lower than the eligibility ceiling for the WIC program, ranging from 33 percent of the poverty level in Texas to 88 percent of the poverty level in Minnesota. Since 1987, Medicaid has increased the income eligibility standards for pregnant women and children. Currently, states are required to expand Medicaid coverage to pregnant women and children whose incomes are below 133 percent of the federal poverty level; in addition, states currently have the option to provide coverage up to 185 percent of the poverty level.

FINDINGS FROM THE LITERATURE

As the WIC program has expanded over the last two decades, numerous and varied evaluations of the WIC program have been conducted. This section summarizes the findings of WIC impact studies that have examined infant mortality, or the three outcomes that are closely related to infant mortality: birthweight, fetal mortality, and gestational age.

Seven major studies of the effects of the WIC program were conducted after the program's inception in 1972 and examined at least one of the variables of interest (infant mortality, birthweight, fetal mortality, and gestational age). The primary findings of these studies are discussed below:

- The earliest evaluation, Edozien et al. (1979), was a national study of over 50,000 women, infants, and children at 19 WIC projects in 14 states. Outcomes from clinical examinations and laboratory samples collected between 1973 and 1976 for current WIC participants were compared with similar measures for new WIC enrollees at the time of their enrollment. The primary study finding was that WIC participation during pregnancy resulted in increased birthweight.

- Kennedy et al. (1982) compared medical and nutritional records collected between 1973 and 1978 for the births of 897 WIC participants with those of 400 pregnant women who were either on WIC waiting lists or were receiving health services at non-WIC facilities at nine sites in Massachusetts. WIC participants had higher average birthweights than nonparticipants (3,273 grams versus 3,136 grams).

- Kotelchuck et al. (1984) examined 4,126 matched pairs of births for WIC participants and nonparticipants from 1978 birth and death certificates and WIC program records in Massachusetts. Prenatal WIC participation was associated with a significant decrease in infant mortality, a lower percentage of low birthweight newborns, and increased gestational age.

- Metcoff et al. (1985) examined a sample of 824 WIC-eligible pregnant women who were attending prenatal clinics in Oklahoma; half of the sample was assigned randomly to a WIC treatment group and half to a control group. Average newborn birthweight was higher for WIC participants than for the control group (from 3,163 to 3,254 grams), based on regression techniques which controlled for selected characteristics of the mother and her pregnancy.

- Schramm (1985, 1986, and 1989). In three studies of Medicaid-covered births in Missouri, prenatal WIC participation was associated with increased birthweight and a lower percentage of low birthweight newborns.

- Stockbauer (1986 and 1987). In the 1986 study the author found mixed effects on birthweight, depending on which comparison sample was used. However, he found that black WIC participants consistently had newborns with higher

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birthweights than black nonparticipants. The study was based on a comparison of WIC participants and several different groups of nonparticipants. In the 1987 study Stockbauer found that relative to nonparticipants, WIC participants had a lower percentage of low birthweight newborns. This study compared matched pairs of WIC and non-WIC births. Both studies found that at least 7 months of WIC participation were required to observe improved birthweight outcomes.

- Rush (1986) compared longitudinal data on 5,205 prenatal WIC participants and 1,358 non-WIC registrants at prenatal clinics selected from 174 WIC sites and 55 clinics across the country. The primary findings concerning the effects of prenatal WIC participation on measures or correlates of infant mortality are: no statistically significant effect on newborn birthweight; increased birthweight with better WIC program quality; no statistically significant effect on gestational age; and a lower incidence of fetal death and low birthweight of appreciable but not significant magnitude.

These evaluations shared a number of features. Each examined the ability of WIC participation to increase birthweight. Low birthweight is known to predict subsequent short- and long-term health problems in newborns, such as respiratory difficulties and developmental disabilities (Institute of Medicine, 1985). In addition, low birthweight is a primary determinant of infant mortality and morbidity (McCormick 1985). Neonatal and infant mortality rates are considerably higher for low-birthweight newborns relative to newborns that are not low birthweight. One study found that, relative to normal-birthweight newborns, low-birthweight newborns were 40 times more likely to die in the neonatal period (Shapiro et al. 1980).

The General Accounting Office (GAO) conducted a review of WIC evaluations in 1984 to assess the effectiveness of the WIC program in reducing the likelihood of adverse pregnancy outcomes. Because of the methodological limitations of these studies, GAO felt that there was not sufficient information to make a conclusive judgement of the effectiveness of the WIC program. Most importantly for this analysis of infant mortality, while GAO concluded that WIC evaluation studies gave some support for the ability of the WIC program to increase birthweight, they found substantially less data to support claims that the WIC program decreased fetal and neonatal deaths.

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Determining an effect of prenatal WIC participation on infant mortality is difficult. Few studies have examined infant mortality, while more have examined measures that are related to infant mortality. Many WIC evaluations are plagued by potentially serious methodological problems, such as sample attrition or an inadequate comparison group methodology. In addition, infant deaths are relatively infrequent events, requiring researchers to have extremely large sample sizes to detect an effect if one is present. With nearly 105,000 Medicaid births across the five study states, the WIC-Medicaid database provides an opportunity to assess the relationship between WIC participation during pregnancy and infant mortality.

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III. ANALYSIS OF INFANT MORTALITY

This chapter describes the results from descriptive and multivariate analyses of infant mortality among Medicaid newborns. The descriptive analysis examines the incidence of infant mortality by maternal and newborn characteristics. The multivariate analysis examines the relationship between infant mortality and prenatal WIC participation when other factors are controlled for.

DESCRIPTIVE ANALYSIS OF INFANT MORTALITY

The incidence of infant mortality among Medicaid newborns varied significantly across the five study states, as shown in Table 1. Infant mortality rates of Medicaid newborns, defined as the number of deaths to infants under one year of age per 1,000 live Medicaid births, ranged from 10.4 in Florida to 13.3 in Minnesota to 16.2 and 16.6 in North Carolina and South Carolina, respectively.[1] At six months of age, infant death rates were lowest for Florida and Texas at 9.4 and 9.8 deaths per 1,000 live births, respectively, and highest for South Carolina and North Carolina with rates of 14.3 and 14.7, respectively. Infant death rates during the first 28 days after birth were, on average, between 50 and 60 percent of the annual infant mortality rates and ranged from 5.5 deaths per 1,000 live births in Texas to 9.2 in South Carolina. With the exception of Florida, the infant mortality rate for Medicaid newborns exceeded the infant mortality rate for all newborns in each state.

The infant mortality rate for Medicaid newborns is strongly related to gestational age and birthweight, as shown in Table 2. Infant mortality rates are very high for newborns born at less than 28 weeks gestation and for those with very low birthweight (birthweight less than 1,500 grams). Between one-quarter and one-half of newborns born at less than 28 weeks gestation died within the first year of birth, and between 20 and 30 percent of very low-birthweight newborns died within one year of birth. Although less extreme, infant mortality rates for newborns born at 28 to 32 weeks gestation or for newborns with moderately low birthweight

[1]Recall that the infant death data for Texas refer only to six months after birth, rather than one year as in the other four states.

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TABLE 1

INFANT MORTALITY RATES IN THE FIVE STUDY STATES, 1987

	Medicaid Newborns			All Newborns
	Died Within 28 Days of Birth	Died Within 6 Months of Birth	Died Within 1 Year of Birth	Died Within 1 Year of Birth
Florida	6.1	9.4	10.4	10.6
Minnesota	6.2	11.7	13.3	8.7
North Carolina	8.4	14.7	16.2	11.9
South Carolina	9.2	14.3	16.6	12.7
Texas	5.5	9.8	n.a.	9.1

SOURCE: WIC-Medicaid newborn database and National Center for Health Statistics 1989.

NOTE: The infant mortality rates are the number of infant deaths per 1,000 live births.

n.a.: not available.

TABLE 2

INFANT MORTALITY AMONG MEDICAID NEWBORNS BY
GESTATIONAL AGE AND BIRTHWEIGHT

	Florida	Minnesota	North Carolina	South Carolina	Texas[a]
Total					
Number of Infant Deaths	374	156	336	196	252
Infant Deaths Per 1,000 Live Births	10.4	13.3	16.2	16.6	9.8
Gestational Age					
< 28 Weeks					
Number of Infants Deaths	92	37	98	53	52
Infant Deaths Per 1,000 Live Births	260.6	528.6	360.3	417.3	218.5
28-30 Weeks					
Number of Infants Deaths	31	9	21	14	18
Infant Deaths Per 1,000 Live Births	68.1	125.0	71.7	74.5	59.6
31-32 Weeks					
Number of Infants Deaths	25	10	11	11	16
Infant Deaths Per 1,000 Live Births	42.7	131.6	31.3	46.4	40.3
> 32 Weeks					
Number of Infants Deaths	195	91	206	118	138
Infant Deaths Per 1,000 Live Births	5.8	8.4	10.4	10.6	5.9
Unknown					
Number of Infants Deaths	31	9	0	0	28
Infant Deaths Per 1,000 Live Births	30.9	14.2	0	0	18.7
Birthweight					
< 1,500 Grams					
Number of Infants Deaths	164	50	149	90	95
Infant Deaths Per 1,000 Live Births	210.8	294.1	252.5	306.1	186.3
1,500-2,499 Grams					
Number of Infants Deaths	57	37	52	35	51
Infant Deaths Per 1,000 Live Births	16.7	44.4	25.4	28.7	22.8
2,500 Grams and Over					
Number of Infants Deaths	150	65	135	71	103
Infant Deaths Per 1,000 Live Births	4.7	6.1	7.5	7.0	4.5

SOURCE: WIC/Medicaid newborn database.

NOTE: The infant mortality rate is the number of deaths to Medicaid infants less than one year of age per 1,000 live births. In Texas, the rate refers to deaths of infants less than or equal to six months of age.

[a]Infants deaths refer to deaths of infants less than or equal to six months of age.

(1,500-2,499 grams) were also considerably higher than average. In contrast, the incidence of infant mortality for Medicaid newborns with gestational age greater than 32 weeks was quite low, at roughly 5.6 infant deaths per 1,000 live births.

This strong relationship among gestational age, birthweight, and infant mortality has important implications for an analysis of the impacts of prenatal WIC participation on infant mortality. The primary WIC participation variable used in the WIC-Medicaid study is a simple binary variable that equals one if the woman participated in the WIC program any time during her pregnancy and equals zero otherwise. Thus, WIC participants include some women who enrolled early in pregnancy and some who enrolled late in pregnancy. The pregnancy outcomes are likely to be more favorable for the group of later WIC enrollees relative to early enrollees in the WIC program for reasons that are related mostly to longer pregnancy durations rather than to prenatal WIC participation. In addition, for the later enrollees, there is the potential for an overstatement of the effects of prenatal WIC participation since birth outcomes for late WIC enrollees with longer gestational ages are compared with the birth outcomes for nonparticipants, some of whom had low-gestational age births and did not have the opportunity to enroll later as prenatal WIC participants.

This issue of the timing of prenatal WIC enrollment is particularly important in the context of an analysis of infant mortality. If a woman enrolls in the WIC program late during pregnancy (e.g., after 32 weeks gestation), she is less likely to have an infant who dies for the simple reason that the incidence of infant mortality drops sharply with gestational age. That is, late WIC enrollees are likely to have higher birthweight newborns and are less likely to have newborns who die, yet it would be incorrect to attribute the effect of the duration of pregnancy on birth outcomes to WIC participation.

To account for the relationship between gestational age and the incidence of infant mortality, we define WIC participants as women who enrolled in the WIC program before 30 weeks gestation. Specifically, prenatal WIC participation is defined such that if a woman enrolled in the WIC program after 30 weeks gestation and the value of her redeemed food instruments was less than $80 (for the three states with food instrument redemption data) then she was considered a nonparticipant. The threshold of $80 for the value of the redeemed food instruments is used to redefine late WIC enrollees with less than 3 months of food instruments as nonparticipants.

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In South Carolina, a WIC enrollee is considered a nonparticipant if she enrolled after 30 weeks gestation and if the number of food instruments was less than 3. In Texas, a WIC enrollee is considered a nonparticipant if she enrolled after 30 weeks gestation. (Texas was not able to provide data on the number of food instrument issued or redeemed.)

Additional descriptive data on the incidence of infant mortality among Medicaid newborns are presented in Table 3. In all five states, the infant mortality rate of Medicaid newborns was lower for prenatal WIC participants than for nonparticipants. The largest difference in the infant mortality rates between WIC participants and nonparticipants was observed in South Carolina, where nonparticipants had an infant mortality rate that was approximately four times larger than the infant mortality rate for WIC participants. In North Carolina, the infant mortality rate for nonparticipants was nearly twice the infant mortality rate for prenatal WIC participants. In Florida, Minnesota, and Texas, the differences between WIC participants and nonparticipants were smaller, with the infant mortality rates for nonparticipants between 25 and 80 percent larger than the infant mortality rates for WIC participants.

Racial differences in infant mortality rates varied across the study states; in Florida and Minnesota, infant mortality rates for black Medicaid mothers were higher than the infant mortality rates for white Medicaid mothers; in North Carolina and South Carolina, the infant mortality rates of white and black Medicaid mothers were roughly equal; and in Texas, the infant mortality rate for black Medicaid mothers was less than the infant mortality rate for white Medicaid mothers.

Differences in infant mortality rates by marital status and age were generally small, although, in Minnesota, the infant mortality rate for married Medicaid mothers exceeded the infant mortality rate for unmarried Medicaid mothers. In Minnesota and South Carolina, the infant mortality rates were higher than average for women less than 18 years of age, while in Florida and Texas, the infant mortality rates were higher than average for women aged 35 years and older. As expected, plurality is strongly related to infant mortality, with multiple births considerably more likely to die within the first year of life than singleton births.

Substantial differences in infant mortality rates are observed for women who differed in the adequacy of prenatal care as measured by the Kessner

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TABLE 3

DESCRIPTIVE DATA ON INFANT MORTALITY AMONG MEDICAID NEWBORNS

	Florida	Minnesota	North Carolina	South Carolina	Texas[a]
Total					
Number of Infant Deaths	374	156	336	196	252
Infant Deaths Per 1,000 Live Births	10.4	13.3	16.2	16.6	9.8
WIC Participation					
Participants by 30 Weeks					
Number of Infant Deaths	145	90	162	73	56
Infant Deaths Per 1,000 Live Births	7.5	12.1	12.1	8.7	6.5
Nonparticipants by 30 Weeks					
Number of Infant Deaths	229	66	174	123	196
Infant Deaths Per 1,000 Live Births	13.7	15.3	23.7	36.9	11.4
Race/Ethnicity of Mother[b]					
White					
Number of Infant Deaths	115	112	115	53	68
Infant Deaths Per 1,000 Live Births	7.3	12.6	15.1	17.5	11.5
Black					
Number of Infant Deaths	227	25	221	143	58
Infant Deaths Per 1,000 Live Births	13.6	22.7	16.9	16.4	8.1
Hispanic					
Number of Infant Deaths	31	--	--	--	93
Infant Deaths Per 1,000 Live Births	9.5	--	--	--	8.8
Native American					
Number of Infant Deaths	--	12	--	--	--
Infant Deaths Per 1,000 Live Births	--	14.5	--	--	--
Marital Status					
Married					
Number of Infant Deaths	113	104	99	50	134
Infant Deaths Per 1,000 Live Births	9.0	15.5	15.0	14.2	10.9
Not Married					
Number of Infant Deaths	260	52	237	146	116
Infant Deaths Per 1,000 Live Births	11.2	10.3	16.8	17.7	8.6
Age of Mother					
< 18 Years of Age					
Number of Infant Deaths	43	19	54	31	23
Infant Deaths Per 1,000 Live Births	10.0	21.2	18.8	20.2	8.1
18-19 Years of Age					
Number of Infant Deaths	61	32	66	41	41
Infant Deaths Per 1,000 Live Births	10.2	16.1	16.8	17.6	8.4
20-34 Years of Age					
Number of Infant Deaths	251	99	208	119	176
Infant Deaths Per 1,000 Live Births	10.3	11.8	15.5	15.6	10.3
35 Years and Older					
Number of Infant Deaths	19	6	8	5	12
Infant Deaths Per 1,000 Live Births	16.3	12.3	16.5	18.1	12.8

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TABLE 3 *(continued)*

	Florida	Minnesota	North Carolina	South Carolina	Texas[a]
Plurality					
Singleton					
Number of Infant Deaths	341	145	306	178	222
Infant Deaths Per 1,000 Live Births	9.7	12.7	15.2	15.5	8.8
Multiple Birth					
Number of Infant Deaths	33	11	30	18	30
Infant Deaths Per 1,000 Live Births	37.0	36.5	53.5	62.7	45.5
Kessner Index					
Inadequate					
Number of Infant Deaths	93	27	63	58	64
Infant Deaths Per 1,000 Live Births	17.5	23.3	33.7	28.2	12.5
Intermediate					
Number of Infant Deaths	140	48	145	80	89
Infant Deaths Per 1,000 Live Births	8.7	11.8	17.3	13.8	8.3
Adequate					
Number of Infant Deaths	112	49	115	54	65
Infant Deaths Per 1,000 Live Births	8.5	10.2	11.5	14.6	8.2
Unknown					
Number of Infant Deaths	29	32	13	4	34
Infant Deaths Per 1,000 Live Births	24.7	18.6	26.4	18.3	16.6

SOURCE: WIC-Medicaid newborn database.

NOTE: The infant mortality rate is the number of deaths to Medicaid infants less than one year of age per 1,000 live births. In Texas, the rate refers to deaths of infants less than or equal to six months of age.

[a]Infant deaths refer to deaths of infants less than or equal to six months of age.

[b]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish."

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Index of prenatal care adequacy. In particular, women who received inadequate levels of prenatal care had substantially higher infant mortality rates than women who received either intermediate or adequate levels of prenatal care. Interestingly, women with missing data on the adequacy of prenatal care (because of missing data on either gestational age, number of prenatal care visits, or the timing of the first prenatal care visit) also had higher than average rates of infant mortality.

With the exception of Minnesota, more than half of the deaths to Medicaid infants within the first year of life (six months in Texas) occurred within the first 28 days after birth, as shown by the neonatal mortality rates in Table 4. In Minnesota, about 46 percent of the Medicaid infant deaths during the first year of life occurred in the neonatal period. Differences in the infant death rates between prenatal WIC participants and nonparticipants are proportionately greater for the neonatal period than for the postneonatal period. The difference between nonparticipants and prenatal WIC participants in the number of neonatal infant deaths ranges from 1.5 deaths per 1,000 live births in Minnesota to 19.4 in South Carolina. The difference in the postneonatal mortality rates is somewhat smaller, ranging from 1.7 deaths per 1,000 live births in Minnesota to 8.8 in South Carolina.

MULTIVARIATE ANALYSIS OF INFANT MORTALITY

The multivariate analysis of infant mortality examines the relationship between the likelihood of an infant death and prenatal WIC participation. As suggested by the descriptive analysis, prenatal WIC participation may have a greater effect on the likelihood of an infant death shortly after birth than later during infancy. Therefore, three dichotomous dependent variables were used in separate multivariate specifications:

- ***Infant Mortality***, a variable equal to one if the newborn died within one year of birth and equal to zero otherwise
- ***Neonatal Mortality***, a variable equal to one if the newborn died within 28 days of birth and equal to zero otherwise
- ***Postneonatal Mortality***, a variable equal to one if the newborn died between 28 days and one year after birth and equal to zero otherwise

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TABLE 4

INFANT, NEONATAL, AND POSTNEONATAL MORTALITY RATES AMONG MEDICAID NEWBORNS

	Infant Mortality Rate[a]	Neonatal Mortality Rate[b]	Postneonatal Mortality Rate[c]
Florida			
Total	10.4	6.1	4.3
WIC Participants by 30 Weeks	7.5	4.3	3.2
Nonparticipants by 30 Weeks	13.7	8.2	5.5
Minnesota			
Total	13.3	6.2	7.1
WIC Participants by 30 Weeks	12.1	5.7	6.4
Nonparticipants by 30 Weeks	15.3	7.2	8.1
North Carolina			
Total	16.2	8.4	7.8
WIC Participants by 30 Weeks	12.1	5.2	6.9
Nonparticipants by 30 Weeks	23.7	14.0	9.7
South Carolina			
Total	16.6	9.2	7.4
WIC Participants by 30 Weeks	8.7	3.7	5.0
Nonparticipants by 30 Weeks	36.9	23.1	13.8
Texas			
Total	9.8	5.5	4.3
WIC Participants by 30 Weeks	6.5	3.5	3.0
Nonparticipants by 30 Weeks	11.4	6.7	4.7

SOURCE: WIC-Medicaid newborn database.

[a]Number of deaths to Medicaid infants less than one year of age per 1,000 live births. In Texas, the rate refers to deaths of infants less than or equal to six months of age.

[b]Deaths to Medicaid infants within 28 days after birth per 1,000 live births.

[c]Deaths to Medicaid infants between 28 days and one year after birth per 1,000 live births. In Texas, the postneonatal mortality rate refers to deaths of infants between 28 days after birth and less than or equal to 6 months of age.

The model estimated for this analysis is a reduced-form model of infant mortality in which the infant death rates are a function of a set of exogenous variables.[2] In addition to prenatal WIC participation, the following variables were included as predictors of the infant death rates (if they were available in the state's database): the sex of the newborn, multiple birth, maternal age, mother's race/ethnicity, marital status, prenatal care adequacy, number of previous live births, number of previous pregnancy terminations, mother's education, urban residence, and whether the mother received prenatal care from a public health clinic.

Probit, a maximum likelihood estimation procedure for dichotomous dependent variables, was used to estimate the state-specific infant mortality models. Estimated probit coefficients do not have simple, intuitive interpretations except to show the directions of the effects of the independent variables on the likelihood or probability of an infant death. However, the estimated coefficients can be used to calculate the predicted infant, neonatal, or postneonatal mortality rates with and without prenatal WIC participation. These predicted rates are constructed by computing for each observation the predicted probability that the newborn dies within a specific time period after birth when the WIC participation variable is set equal to 0 (nonparticipant) for all observations and when it is set equal to 1 (participant) for all observations. These probabilities are then averaged, and the resulting averages are multiplied by 1,000 to obtain the predicted mortality rates with and without the WIC program. Similarly, predicted infant death rates for differing levels of prenatal care can be constructed from probit coefficients. Predicted infant, neonatal, and postneonatal mortality rates, as well as the estimated probit

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[2]We also estimated a structural model of newborn birthweight and infant mortality in which birthweight depends on prenatal WIC participation (and other factors) and infant mortality depends on both birthweight and prenatal WIC participation (and other factors). The structural model specifies two effects of WIC participation on infant mortality--a direct effect, controlling for birthweight, and an indirect effect operating through WIC's effect on birthweight and birthweight's effect on infant mortality. Unfortunately, it is very difficult to separate the effects of the explanatory variables (especially prenatal WIC participation) on birthweight from their effects on infant mortality. As a result, the parameter estimates had large standard errors and the structural model was estimated very imprecisely. Appendix B describes further the structural model of infant mortality and birthweight and includes detailed analysis results.

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coefficients of prenatal WIC participation and prenatal care adequacy, are presented in Table 5. Detailed probit results are presented in Appendix A.

Prenatal WIC Participation

Prenatal WIC participation by 30 weeks gestation is generally associated with significant reductions in infant mortality with most of the decline attributable to reductions in neonatal mortality. Specific findings are the following:

- ***Infant Mortality***. With the exception of Minnesota, the predicted infant mortality rates with the WIC program are roughly one-quarter to two-thirds the predicted infant mortality rates without the WIC program. The estimated reductions in infant mortality rates resulting from prenatal WIC participation are 3.6 infant deaths per 1,000 live births in Florida, 4.0 deaths per 1,000 live births in Texas, 8.4 deaths per 1,000 live births in North Carolina, and 27.2 deaths per 1,000 live births in South Carolina.

- ***Neonatal Mortality***. The proportionate reductions in neonatal mortality rates for prenatal WIC participants are larger than the proportionate reductions in infant mortality rates. With the exception of Minnesota, the predicted neonatal mortality rates with the WIC program are roughly one-sixth to two-thirds the predicted neonatal mortality rates without the WIC program. The estimated reductions in neonatal mortality rates resulting from prenatal WIC participation are 2.3 neonatal deaths per 1,000 live births in Florida, 3.0 in Texas, 7.3 in North Carolina, and 19.9 in South Carolina.

- ***Postneonatal Mortality***. With the exception of South Carolina, prenatal WIC participation is not significantly related to postneonatal mortality. In South Carolina, the estimated difference between postneonatal mortality rates with and without WIC is 7.5 deaths per 1,000 live births, implying a 60 percent reduction in postneonatal mortality associated with prenatal WIC participation. For the other states, the differences in postneonatal mortality rates associated with WIC are less than 1.3 and are not statistically significant.

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TABLE 5

ESTIMATED EFFECTS OF PRENATAL WIC PARTICIPATION ON DEATH RATES OF MEDICAID NEWBORNS

	Probit Coefficient	Mortality Rate for Medicaid Newborns: Without WIC	With WIC	Difference
Florida				
Infant Mortality Rate	-.140**	11.9	8.3	3.6
Neonatal Mortality Rate	-.147**	6.9	4.6	2.3
Postneonatal Mortality Rate	-.105	5.0	3.7	1.3
Minnesota				
Infant Mortality Rate	-.036	14.0	12.8	1.2
Neonatal Mortality Rate	.019	6.0	6.3	-.3
Postneonatal Mortality Rate	-.073	8.1	6.6	1.5
North Carolina				
Infant Mortality Rate	-.205**	21.3	12.9	8.4
Neonatal Mortality Rate	-.315**	12.8	5.5	7.3
Postneonatal Mortality Rate	-.057	8.6	7.4	1.2
South Carolina				
Infant Mortality Rate	-.587**	36.0	8.8	27.2
Neonatal Mortality Rate	-.720**	23.6	3.7	19.9
Postneonatal Mortality Rate	-.335**	12.7	5.2	7.5
Texas				
Infant Mortality Rate[a]	-.169 **	11.1	7.1	4.0
Neonatal Mortality Rate	-.208 **	6.6	3.6	3.0
Postneonatal Mortality Rate[a]	-.099	4.6	3.4	1.2

SOURCE: WIC-Medicaid newborn database.

NOTE: Mortality rates are the number of deaths to Medicaid infants per 1,000 live births.

[a]Refers to deaths to Medicaid infants less than or equal to 6 months of age.

*(**): Significant at .05(.01) level.

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While these results suggest that prenatal WIC participation is associated with reductions in infant death rates of Medicaid newborns, significant differences are found in the magnitude of the WIC effects across the study states. The estimated effect of prenatal WIC participation by Medicaid beneficiaries on the incidence of infant mortality was greatest for South Carolina, while no statistically significant effect was found for Minnesota. Interstate comparisons of study findings must be made cautiously, however, since the characteristics of the WIC and Medicaid populations differed considerably across the study states, and such differences are important factors in the assessment of the effects of WIC participation.

Specifically, in 1987, the characteristics of the Medicaid-eligible populations differed considerably across the five study states. Medicaid beneficiaries in Minnesota were predominantly white and married, were somewhat older, and had more years of education than those in the other four states (Devaney, Bilheimer, and Schore 1990). In addition, because of differences in the income-eligibility standards across the states, the Medicaid populations in the study states were not comparable socioeconomically. In 1987, the poverty income threshold for a family of three was $9,056; across the five study states, the Medicaid income eligibility thresholds ranged from 33 percent of the poverty level in Texas ($2,988 for a family of three) to 88 percent in Minnesota ($7,969 for a family of three). The other three states had income eligibility thresholds between 40 and 50 percent of the poverty level. The differences in Medicaid income eligibility across the states during the study period are likely to have a significant effect on the study findings and must be considered when the implications of the analysis findings are assessed. A priori, one would expect that the benefits of WIC program participation would be greatest among the most severely disadvantaged women. This expectation is consistent with the apparently smaller program impact in Minnesota.

An important caveat to these findings is that the estimated effects of prenatal WIC participation are not independent of any unmeasured differences between WIC participants and nonparticipants that may also influence infant death rates. WIC participants are a self-selected group of women who may choose to participate in the WIC program for underlying reasons that may independently lead to lower infant death rates. For example, some pregnant women may not participate in the WIC program because they lack access to or knowledge of publicly funded programs that provide health care or other services, which also may affect

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pregnancy outcomes. Thus, the estimated effects of prenatal WIC participation on infant death rates may overstate the true effects since, relative to nonparticipants, WIC participants would have lower infant death rates even in the absence of the WIC program. Conversely, if the WIC program is successful at reaching high-risk, low-income pregnant women, infant death rates of WIC participants may be higher than for nonparticipants, and the estimated effects of prenatal WIC participation would understate the true effects.

In the absence of a true experimental design in which WIC-eligible pregnant women would be randomly assigned to treatment and control groups, it is extremely difficult to control for the effects of self-selection when estimating the effects of prenatal WIC participation on infant mortality. However, the problem introduced by self-selection may be offset to some extent by the facts that: (1) the adequacy of prenatal care is also likely to be related to any such underlying differences between WIC participants and nonparticipants, and (2) the model controls for the adequacy of prenatal care in estimating the effects of prenatal WIC participation. However, the potential implications of the self-selection issue should be kept in mind when interpreting the study findings.[3]

The analytic issues raised by the self-selection of WIC participants may be particularly important for South Carolina, where the results indicate a very large and statistically significant difference of 27.2 infant deaths per 1,000 live Medicaid births between WIC participants and nonparticipants. Of the five study states, South Carolina had the highest infant mortality rate among Medicaid newborns at 16.6 infant deaths per 1,000 live Medicaid births and the highest prenatal WIC participation rate among Medicaid beneficiaries at 75 percent. Infant mortality rates among the relatively small percentage of Medicaid newborns whose mothers did not participate in WIC during pregnancy were very high, as shown by both the descriptive results presented in Table 3 and the multivariate results summarized in Table 5. It is likely that these nonparticipants differed in important and unobserved ways from WIC participants, and that these differences at least partially explain the very large differences in infant mortality between WIC participants and nonparticipants.

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[3]We estimated several selection bias models for the WIC-Medicaid study. Unfortunately, because of the very limited set of independent variables from the birth files, the selection bias models estimated for this study yielded very unrealistic results that were extremely sensitive to both minor changes in model specification and the estimation procedure employed.

Adequacy of Prenatal Care

The incidence of infant mortality is also significantly related to the adequacy of prenatal care, as shown in Table 6 and in the detailed tables contained in Appendix A. In all five states, receiving inadequate versus either adequate or intermediate levels of prenatal care is associated with a higher likelihood of an infant death. These findings are consistent with the earlier WIC-Medicaid study findings that the adequacy of prenatal care is significantly related to birth outcomes, above and beyond the effects of prenatal WIC participation (Devaney, Bilheimer, and Schore 1990).

An interesting result shown in Table 6 is that receiving inadequate levels of prenatal care has a stronger effect on the likelihood of a postneonatal death than on the likelihood of a neonatal death. The estimated coefficients of inadequate prenatal care in the neonatal probits are statistically significant only for Florida and North Carolina. In contrast, for all five states, receiving inadequate levels of prenatal care is consistently associated with a higher likelihood of a postneonatal infant death.

SUMMARY

In summary, prenatal WIC participation in Florida, North Carolina, South Carolina, and Texas is associated with a reduction in the likelihood of an infant death. In Minnesota, prenatal WIC participation is not significantly related to the incidence of infant mortality.

For women enrolling in the WIC program by 30 weeks gestation, the estimated reduction in the infant mortality rate is 3.6 deaths per 1,000 live births in Florida, 8.4 in North Carolina, 27.2 in South Carolina, and 4.0 in Texas. Although these effects may seem small, it is important to remember that infant deaths occur rarely compared to the number of births, and, consequently, these participant-nonparticipant differences represent large differences in the numbers of infants that die. As shown in Table 7, with the exception of Minnesota, the estimated number of infant deaths prevented by prenatal WIC participation by 30 weeks gestation ranges from 114 deaths in Florida to 320 deaths in South Carolina, with intermediate values of 103 deaths in Texas and 174 deaths in North Carolina.

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TABLE 6

ESTIMATED EFFECTS OF PRENATAL CARE ADEQUACY ON DEATH RATES OF MEDICAID NEWBORNS

	Probit Coefficient		Mortality Rate for Medicaid Newborns		
	Prenatal Care Inadequate	Prenatal Care Intermediate	Prenatal Care Inadequate	Prenatal Care Intermediate	Prenatal Care Adequate
Florida					
Infant Mortality Rate	.244 **	.034	15.2	8.9	8.2
Neonatal Mortality Rate	.170 *	.005	8.0	5.1	5.0
Postneonatal Mortality Rate	.292 **	.069	7.2	3.9	3.2
Minnesota					
Infant Mortality Rate	.279 **	.026	21.5	11.6	10.8
Neonatal Mortality Rate	.242	-.155	10.5	3.6	5.5
Postneonatal Mortality Rate	.272 *	.140	11.2	7.8	5.3
North Carolina					
Infant Mortality Rate	.344 **	.147 **	27.0	17.0	11.8
Neonatal Mortality Rate	.221 *	.081	11.6	8.1	6.5
Postneonatal Mortality Rate	.409 **	.190 **	15.7	8.9	5.3
South Carolina					
Infant Mortality Rate	.130	-.036	21.1	14.3	15.6
Neonatal Mortality Rate	-.078	-.109	8.7	8.0	10.5
Postneonatal Mortality Rate	.326 **	.048	13.1	6.3	5.5
Texas					
Infant Mortality Rate[a]	.158 *	.017	12.1	8.4	8.0
Neonatal Mortality Rate	.061	-.085	6.5	4.5	5.5
Postneonatal Mortality Rate[a]	.274 **	.160	5.6	4.0	2.5

SOURCE: WIC-Medicaid newborn database.

NOTE: Mortality rates are the number of deaths to Medicaid infants per 1,000 live births.

[a]Refers to deaths to Medicaid infants less than or equal to 6 months of age.

*(**): Significant at .05(.01) level.

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TABLE 7

ESTIMATED NUMBER OF INFANT DEATHS PREVENTED
BY PRENATAL WIC PARTICIPATION

	Actual Number of Infant Deaths	Estimated Number of Infant Deaths Prevented[a]
Florida	374	114
Minnesota	156	0
North Carolina	336	174
South Carolina	196	320
Texas[b]	252	103

SOURCE: WIC-Medicaid newborn database.

[a]Calculated by multiplying the estimated reduction in infant mortality rates due to prenatal WIC participation by 30 weeks (Table 5) by the total number of Medicaid births during the study period for each state (Appendix Table A.1).

[b]Deaths to infants less than or equal to 5 months of age.

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APPENDIX A

ESTIMATED PROBIT COEFFICIENTS FOR MODELS OF INFANT MORTALITY, NEONATAL MORTALITY, AND POSTNEONATAL MORALITY AMONG MEDICAID NEWBORNS

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TABLE A.1

ESTIMATED PROBIT COEFFICIENTS FOR A MODEL OF THE EFFECT OF PRENATAL WIC PARTICIPATION ON INFANT MORTALITY

(Standard Errors in Parentheses)

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-2.723 ** (.133)	-2.238 ** (.172)	-2.192 ** (.119)	-2.052 ** (.173)	-2.314 ** (.102)
Prenatal WIC Participation by 30 Weeks Gestation	-.140 ** (.045)	-.036 (.067)	-.205 ** (.047)	-.587 ** (.062)	-.169 ** (.055)
Newborn Characteristics					
Male	.220 ** (.044)	-.044 (.064)	.075 (.045)	.152 * (.061)	.049 (.048)
Multiple Birth	.626 ** (.089)	.446 ** (.143)	.546 ** (.095)	.669 ** (.126)	.661 ** (.093)
Mother Characteristics					
Age 18-19	.058 (.086)	-.069 (.127)	-.037 (.081)	.059 (.108)	-.016 (.097)
Age 20-34	.031 (.081)	-.200 (.123)	-.091 (.079)	.024 (.098)	.063 (.086)
Age 35 and over	.139 (.144)	-.230 (.217)	-.185 (.179)	.054 (.209)	.117 (.151)
Black[a]	.253 ** (.053)	.136 (.102)	.046 (.054)	-.077 (.075)	-.154 * (.066)
Hispanic[a]	.098 (.086)	--	--	--	-.139 * (.057)
Native American	--	-.060 (.128)	--	--	--
Asian	--	-.294 (.171)	--	--	--
Other race/ethnicity[a]	--	--	--	--	-.195 (.156)
Not married	.008 (.053)	-.110 (.075)	-.016 (.056)	.097 (.075)	-.080 (.052)
Kessner Index inadequate	.244 ** (.063)	.279 ** (.105)	.344 ** (.074)	.130 (.084)	.158 * (.069)
Kessner Index intermediate	.034 (.052)	.026 (.080)	.147 ** (.050)	-.036 (.073)	.017 (.061)
Kessner Index unknown	.283 ** (.106)	.202 * (.098)	.301 ** (.107)	-.042 (.215)	.294 ** (.084)
Previous live births (number)	.030 (.017)	.019 (.028)	.00009 (.022)	--	-.007 (.019)
Pregnancy terminations weeks	--	.099 ** (.034)	.108 ** (.033)	--	.005 (.101)

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TABLE A.1 *(continued)*

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Mother Characteristics (continued)					
Education < 9 years	.200	.313	.018	.402 **	--
	(.107)	(.193)	(.113)	(.117)	
Education 9-11 years	.084	.122	.006	.164	--
	(.084)	(.122)	(.080)	(.117)	
Education 12 years	.085	.113	-.042	.092	--
	(.080)	(.111)	(.075)	(.114)	
Education missing	--	.369 **	--	--	--
		(.139)			
Urban	-.069	-.045	.055	-.113	--
	(.065)	(.073)	(.045)	(.061)	
Prenatal care from public health clinic	-.088	--	--	--	--
	(.071)				
Sample Size	31,747	11,564	20,687	11,773	25,746

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if the Medicaid newborn died within one year after birth, and equal to zero otherwise. In Texas, the dependent variable is equal to one if the Medicaid newborn died within six months after birth, and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."

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TABLE A.2

ESTIMATED PROBIT COEFFICIENTS FOR A MODEL OF THE EFFECT OF PRENATAL WIC PARTICIPATION ON NEONATAL MORTALITY

(Standard Errors in Parentheses)

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-2.839 **	-2.543 **	-2.422 **	-2.253 **	-2.505 **
	(.162)	(.245)	(.150)	(.231)	(.133)
Prenatal WIC Participation by 30 Weeks Gestation	-.147 **	.019	-.315 **	-.720 **	-.208 **
	(.056)	(.094)	(.061)	(.081)	(.703)
Newborn Characteristics					
Male	.228 **	-.052	.090	.054	.028
	(.056)	(.088)	(.058)	(.077)	(.060)
Multiple Birth	.701 **	.686 **	.762 **	.841 **	.644 **
	(.100)	(.160)	(.103)	(.139)	(.111)
Mother Characteristics					
Age 18-19	-.025	-.079	-.118	-.063	.133
	(.107)	(.162)	(.109)	(.133)	(.127)
Age 20-34	.008	-.341 *	-.016	-.088	.163
	(.099)	(.161)	(.101)	(.118)	(.117)
Age 35 and over	-.035	-.141	-.035	-.460	.206
	(.197)	(.267)	(.225)	(.383)	(.195)
Black[a]	.264 **	.125	.110	-.039	-.180 *
	(.067)	(.137)	(.071)	(.101)	(.084)
Hispanic[a]	.107	--	--	--	-.136
	(.108)				(.071)
Native American	--	-.222	--	--	--
		(.207)			
Asian	--	-.383	--	--	--
		(.245)			
Other race/ethnicity[a]	--	--	--	--	-.119
					(.181)
Not married	.039	-.090	.083	.232 *	-.081
	(.067)	(.104)	(.076)	(.104)	(.064)
Kessner Index inadequate	.170 *	.242	.221 *	-.078	.061
	(.078)	(.142)	(.097)	(.109)	(.084)
Kessner Index intermediate	.005	-.155	.081	-.109	-.085
	(.064)	(.119)	(.066)	(.092)	(.074)
Kessner Index unknown	.234	.230	.309 *	-.038	.181
	(.132)	(.125)	(.130)	(.246)	(.104)
Previous live births (number)	.014	.002	-.047	--	-.025
	(.021)	(.041)	(.030)		(.025)
Pregnancy terminations weeks	--	.108 *	.104 *	--	.118
		(.045)	(.042)		(.095)

TABLE A.2 *(continued)*

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Mother Characteristics (continued)					
Education < 9 years	.106 (.130)	.519 (.269)	-.079 (.147)	.506 ** (.190)	--
Education 9-11 years	-.005 (.099)	.184 (.193)	-.042 (.098)	.227 (.163)	--
Education 12 years	-.001 (.094)	.228 (.178)	-.145 (.091)	.200 (.157)	--
Education missing	--	.574 (.204)	--	--	--
Urban	-.021 (.084)	-.044 (.102)	.050 (.059)	-.140 (.079)	--
Prenatal care from public health clinic	-.157 (.094)	--	--	--	--
Sample Size	31,747	11,564	20,687	11,773	25,746

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if the Medicaid newborn died within 28 days after birth, and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."

TABLE A.3

ESTIMATED PROBIT COEFFICIENTS FOR A MODEL OF THE EFFECT OF PRENATAL WIC PARTICIPATION ON POSTNEONATAL MORTALITY

(Standard Errors in Parentheses)

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-3.119 **	-2.510	-2.555 **	2.487 **	-2.682 **
	(.196)	(.218)	(.165)	.229	(.139)
Prenatal WIC Participation by 30 Weeks Gestation	-.105	-.073	-.057	-.335 **	-.099
	(.063)	(.083)	(.062)	(.082)	(.075)
Newborn Characteristics					
Male	.176 **	-.027	.043	.229 **	.069
	(.061)	(.080)	(.058)	(.082)	(.067)
Multiple Birth	.353 **	-.258	.028	.158	.546 **
	(.139)	(.257)	(.171)	(.228)	(.128)
Mother Characteristics					
Age 18-19	.154	-.045	.024	.193	-.188
	(.121)	(.170)	(.102)	(.155)	(.132)
Age 20-34	.064	-.048	-.156	.154	-.043
	(.116)	(.162)	(.104)	(.144)	(.110)
Age 35 and over	.290	.293	-.350	.411	-.004
	(.186)	(.310)	(.248)	(.238)	(.203)
Black[a]	.200 **	.119	-.020	-.148	-.096
	(.073)	(.128)	(.069)	(.096)	(.091)
Hispanic[a]	.073	--	--	--	-.117
	(.119)				(.080)
Native American	--	.026	--	--	--
		(.148)			
Asian	--	-.183	--	--	--
		(.211)			
Other race/ethnicity[a]	--	--	--	--	-.266
					(.245)
Not married	-.033	-.110	-.102	-.042	-.068
	(.071)	(.094)	(.071)	(.094)	(.072)
Kessner Index inadequate	.292 **	.272 *	.409 **	.326 **	.274 **
	(.086)	(.131)	(.095)	(.111)	(.100)
Kessner Index intermediate	.069	.140	.190 **	.048	.160
	(.073)	(.098)	(.066)	(.100)	(.090)
Kessner Index unknown	.297	.120	.214	-.086	.400 **
	(.144)	(.132)	(.153)	(.349)	(.118)
Previous live births (number)	.041	.031	.044	--	.016
	(.022)	(.035)	(.027)		(.025)
Pregnancy terminations	--	.074	.094 *	--	-.396
		(.044)	(.042)		(.290)

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TABLE A.3 *(continued)*

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Mother Characteristics (continued)					
Education < 9 years	.306	.137	.154	.198	--
	(.159)	(.242)	(.152)	(.184)	
Education 9-11 years	.208	.083	.095	.070	--
	(.131)	(.142)	(.118)	(.144)	
Education 12 years	.207	.036	.106	-.033	--
	(.127)	(.130)	(.112)	(.141)	
Education missing	--	.141	--	--	--
		(.178)			
Urban	-.113	-.033	.053	-.070	--
	(.085)	(.092)	(.058)	(.081)	
Prenatal care from public health clinic	.001	--	--	--	--
	(.091)				
Sample Size	31,747	11,564	20,687	11,773	25,746

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if the Medicaid newborn died between 28 days after birth and one year after birth, and equal to zero otherwise. In Texas, the dependent variable is equal to one if the Medicaid newborn died between 28 days after birth and 6 months after birth, and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."

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APPENDIX B

ESTIMATES FROM A STRUCTURAL MODEL OF INFANT MORTALITY AND LOW BIRTHWEIGHT

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This appendix presents analysis results from estimating a structural model of infant mortality and low birthweight. Conceptually, birthweight depends on prenatal WIC participation (and other factors) and infant mortality depends on both birthweight and prenatal WIC participation (and other factors). Thus, the model specifies two effects of WIC participation on infant mortality--a direct effect, controlling for birthweight, and an indirect effect operating through WIC's effect on birthweight and birthweight's effect on infant mortality. A priori, we would expect most of the effect of WIC to be indirect. We expect this for two reasons: (1) since the main WIC benefit is food supplementation, we would expect the most primary effect of prenatal WIC participation to be higher newborn birthweight, and (2) the previous literature documents clearly that birthweight is the most important predictor of infant mortality.

MODEL

For Medicaid birth i (i = 1, 2, ..., N), the structural equations are:

$$(1) \quad y_{1i}^{*} = \beta_1' X_{1i} + \alpha_1 WIC_i + u_{1i}$$

$$(2) \quad y_{2i}^{*} = \beta_2' X_{2i} + \alpha_2 WIC_i + \gamma_2 y_{1i}^{*} + u_{2i}$$

$$(3) \quad y_{1i} = \begin{cases} 1 \text{ if } y_{1i}^{*} > 0 \\ 0 \text{ otherwise} \end{cases}$$

$$(4) \quad y_{2i} = \begin{cases} 1 \text{ if } y_{2i}^{*} > 0 \\ 0 \text{ otherwise} \end{cases}$$

where y_{1i}^{*} and y_{2i}^{*} are continuous latent variables measuring the propensity for low birthweight and infant mortality, respectively, y_{1i} and y_{2i}--the observed realizations of the underlying latent variables--are binary endogenous variables denoting low birthweight and infant death, respectively, and X_{1i} and X_{2i} are column vectors of exogenous variables with K_1 and K_2 elements, respectively.[1] In this model, the latent variable

[1]In this model, the observed birthweight variable is specified as a dichotomous variable denoting whether the infant was low birthweight (birthweight less than 2,500 grams) or not. We also estimated a model of infant mortality and birthweight with a continuous variable for birthweight,

for the propensity for low birthweight is a determinant of infant mortality, but infant mortality does not determine low birthweight.

One important issue that arises in the estimation of the infant mortality and low birthweight equations is the extent to which the determinants of low birthweight (X_1 variables) are not identical to the determinants of infant mortality (X_2 variables). If the determinants of low birthweight and infant mortality are nearly or almost identical then it is extremely difficult to separate the effect of a given explanatory variable on low birthweight from its effect on infant mortality. In this case, the resulting parameter estimates have large standard errors and are very imprecise.

Table B.1 shows the exogenous variables included in the structural equations. In the infant mortality structural equation, the following variables were included (if they were available in the state's database): low birthweight, prenatal WIC participation by 30 weeks, male, multiple birth, race or ethnicity, Kessner Index variables denoting the adequacy of prenatal care, urban residence, and whether the source of prenatal care was a public health clinic. Variables for the mother's age and education, previous live births, and number of pregnancy terminations were not included in the structural equation for infant mortality, but were included as predictors of low birthweight.

The structural equations (1) and (2) can also be written in reduced form notation, which expresses each of the two endogenous variables (low birthweight and infant mortality) entirely in terms of the exogenous variables. The reduced form equations are:

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but the results from those models were unrealistic and not robust. The most puzzling result was that birthweight had either a very small negative effect or, in two of the states, a positive effect on infant mortality. This finding made little sense in the context of the literature on infant mortality and led us to reconsider the model specification. Specifically, we favored a model in which some threshold value for birthweight (such as low birthweight or very low birthweight) is a predictor of infant mortality, in contrast to a model that specifies (implausibly) a linear effect of birthweight on infant mortality.

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TABLE B.1

EXPLANATORY VARIABLES IN THE STRUCTURAL EQUATIONS FOR LOW BIRTHWEIGHT AND INFANT MORTALITY

Explanatory Variables	Low Birthweight	Infant Mortality
Intercept	X	X
Prenatal WIC Participation by 32 Weeks Gestation	X	X
Low Birthweight		X
Male Newborn	X	X
Multiple Birth	X	X
Mother Age 18-19	X	
Mother Age 20-34	X	
Mother Age 35 and over	X	
Black[a]	X	X
Hispanic[a]	X	X
Native American	X	X
Asian	X	X
Other race/ethnicity[a]	X	X
Not married	X	
Kessner Index inadequate	X	X
Kessner Index intermediate	X	X
Kessner Index unknown	X	X
Previous live births (number)	X	
Pregnancy terminations (number)	X	
Education < 9 years	X	
Education 9-11 years	X	
Education 12 years	X	
Education missing	X	
Urban		X
Prenatal care from public health clinic	X	X

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic."

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$$(5) \quad y_{1i}^{*} = \beta_1' X_{1i} + \alpha_1 WIC_i + u_{1i}$$

$$(6) \quad y_{2i}^{*} = \beta_2' X_{2i} + (\alpha_2 + \gamma_2 \alpha_1) WIC_i + \gamma_2 \beta_i' X_{1i} + (u_{2i} + \gamma_2 u_{1i}),$$

where $(\alpha_2 + \gamma_2\alpha_1)$ is the reduced-form coefficient of prenatal WIC participation in the infant mortality equation. This reduced-form coefficient is also interpreted as the total effect of WIC, which can be separated into an indirect and direct effect as follows:

Indirect effect: $\gamma_2\alpha_1$

Direct effect: α_2

A two-stage limited information estimator was used to estimate this joint model of infant mortality and low birthweight. The first stage involves estimating the reduced form equations for low birthweight and infant mortality using probit, a maximum likelihood estimation procedure for binary dependent variables. The second stage involves estimating the structural coefficients using generalized least squares estimation.

EMPIRICAL RESULTS

Reduced Form Coefficients. Tables B.2 and B.3 present estimates of the reduced form probit coefficients for the infant mortality and low birthweight equations.[2] With only one exception, prenatal WIC participation by 30 weeks gestation is associated with a significant reduction in the likelihood of both an infant death and low birthweight. The one exception is Minnesota, where the reduced-form coefficient of prenatal WIC participation is not statistically significant in the infant mortality equation.

Infant mortality and low birthweight among Medicaid newborns are also significantly related to the adequacy of prenatal care. In four of the five

[2]Probit coefficients do not have an intuitive interpretation except to show the direction of the effects of the independent variables on the likelihood of an infant death. In presenting the structural coefficient estimates below, the coefficients are used to calculate the probability of an infant death with and without prenatal WIC participation.

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TABLE B.2

REDUCED FORM ESTIMATES OF A MODEL OF INFANT MORTALITY AMONG MEDICAID NEWBORNS
(Standard Errors in Parentheses)

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-2.721 **	-2.213 **	-2.192 **	-2.050 **	-2.303 **
	(.145)	(.190)	(.119)	(.174)	(.102)
Prenatal WIC Participation by 30 Weeks Gestation	-.139 **	-.040	-.205 **	-.587 **	-.165 **
	(.047)	(.069)	(.049)	(.063)	(.057)
Newborn Characteristics					
Male	.220 **	-.035	.075	.153 *	.047
	(.046)	(.069)	(.045)	(.063)	(.050)
Multiple Birth	.628 **	.377 *	.545 **	.669 **	.665 **
	(.089)	(.158)	(.010)	(.132)	(.096)
Mother Characteristics					
Age 18-19	.062	-.102	-.036	.058	-.029
	(.090)	(.143)	(.082)	(.116)	(.099)
Age 20-34	.030	-.215	-.091	.023	.052
	(.083)	(.144)	(.081)	(.105)	(.087)
Age 35 and over	.139	-.311	-.185	.053	.102
	(.144)	(.222)	(.180)	(.209)	(.156)
Black[a]	.254 **	.124	.046	-.077	-.146 *
	(.055)	(.109)	(.056)	(.086)	(.067)
Hispanic[a]	.108	--	--	--	-.146 *
	(.089)				(.060)
Native American	--	-.124	--	--	--
		(.142)			
Asian	--	-.323	--	--	--
		(.175)			
Other race/ethnicity[a]	--	--	--	--	-.194
					(.159)
Not married	.003	-.139	-.016	.098	-.092
	(.053)	(.079)	(.057)	(.082)	(.053)
Kessner Index inadequate	.243 **	.291 **	.344 **	.129	.148 *
	(.064)	(.109)	(.076)	(.086)	(.071)
Kessner Index intermediate	.035	.027	.148 **	-.036	.014
	(.053)	(.087)	(.052)	(.077)	(.064)
Kessner Index unknown	.290 **	.199 **	.301 **	-.043	.296 *
	(.111)	(.099)	(.110)	(.207)	(.088)
Previous live births (number)	.030	.026	.0002	--	-.003
	(.017)	(.032)	(.022)		(.019)
Pregnancy terminations	--	.099 **	.109 **	--	.008
		(.037)	(.036)		(.118)
Education < 9 years	.174	.248	.018	.402 **	
	(.113)	(.229)	(.119)	(.146)	

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TABLE B.2 *(continued)*

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Education 9-11 years	.084 (.086)	.115 (.128)	.006 (.086)	.163 (.123)	
Education 12 years	.083 (.083)	.111 (.115)	-.043 (.079)	.092 (.119)	--
Education missing	--	.323 * (.146)	--	--	--
Urban	-.073 (.066)	-.033 (.077)	.055 (.046)	-.113 (.064)	
Prenatal care from public health clinic	-.083 (.072)	--	--	--	--
Sample Size	31,732	11,547	20,687	11,773	25,710

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if the Medicaid newborn died within one year after birth, and equal to zero otherwise. In Texas, the dependent variable is equal to one if the Medicaid newborn died within six months after birth, and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

--: Variable not on the state database.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic."

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TABLE B.3

REDUCED-FORM ESTIMATES OF A MODEL OF LOW BIRTHWEIGHT AMONG MEDICAID NEWBORNS
(Standard Errors in Parentheses)

Explanatory Variable	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-1.440 **	-1.666 **	-1.431 **	-1.228 **	-1.203 **
	(.058)	(.097)	(.064)	(.090)	(.045)
Prenatal WIC Participation by 32 Weeks Gestation	-.172 **	-.104 **	-.196 **	-.255 **	-.104 **
	(.020)	(.067)	(.025)	(.033)	(.024)
Newborn Characteristics					
Male	-.120 **	-.122 **	-.082 **	-.094 **	-.089 **
	(.020)	(.036)	(.023)	(.031)	(.022)
Multiple Birth	1.709 **	1.703 **	1.683 **	1.657 **	1.635 **
	(.050)	(.078)	(.057)	(.081)	(.052)
Mother Characteristics					
Age 18-19	-.047	-.088	-.019	-.069	-.134 **
	(.039)	(.076)	(.044)	(.056)	(.040)
Age 20-34	.027	.014	.050	-.068	-.089 *
	(.036)	(.071)	(.042)	(.051)	(.036)
Age 35 and over	.264 **	.014	.178 **	.140	.018
	(.065)	(.119)	(.084)	(.104)	(.069)
Black[a]	.273 **	.371 **	.215 **	.174 **	.106 **
	(.023)	(.056)	(.028)	(.041)	(.030)
Hispanic[a]	-.083 *	--	--	--	-.119 **
	(.041)				(.028)
Native American	--	-.241 **	--	--	--
		(.078)			
Asian	--	-.081	--	--	--
		(.084)			
Other race/ethnicity[a]	--	--	--	--	-.216 **
					(.072)
Not married	.036	-.039	-.065 *	.065	.028
	(.024)	(.041)	(.029)	(.038)	(.024)
Kessner Index inadequate	.367 **	.512 **	.421 **	.310 **	.269 **
	(.029)	(.059)	(.042)	(.045)	(.031)
Kessner Index intermediate	.0006	.117 **	.279 **	.033	.005
	(.023)	(.044)	(.025)	(.037)	(.027)
Kessner Index unknown	.279 **	.375 **	.535 **	.441 **	.237 **
	(.053)	(.055)	(.058)	(.101)	(.041)
Previous live births (number)	-.014	-.063 **	-.061 **	--	-.033 **
	(.008)	(.015)	(.011)		(.009)
Pregnancy terminations		.099 **	.106 **	--	.168 **
		(.022)	(.019)		(.042)
Education < 9 years	.034	.320 **	.153 **	.091	--
	(.050)	(.110)	(.060)	(.077)	

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TABLE B.3 *(continued)*

Explanatory Variable	Florida	Minnesota	North Carolina	South Carolina	Texas
Mother Characteristics (continued)					
Education 9-11 years	.080 *	.269 **	.114 **	.072	--
	(.036)	(.066)	(.042)	(.056)	
Education 12 years	.003	.194 **	.029	.030	--
	(.034)	(.060)	(.039)	(.054)	
Education missing	--	.254 **	--	--	--
		(.080)			
Urban	.030	-.012	.058 **	-.037	--
	(.031)	(.040)	(.023)	(.031)	
Prenatal care from public health clinic	-.097 **	--	--	--	--
	(.031)				
Sample Size	31,732	11,547	20,687	11,773	25,710

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if newborn birthweight was less than 2,500 grams and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

--: Variable not on the state database.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic."

states, receiving inadequate versus adequate prenatal care is associated with a higher likelihood of an infant death and, in all five states, a higher likelihood of low birthweight. However, receiving intermediate versus adequate levels of prenatal care has no consistent relationship with infant mortality and low birthweight among Medicaid newborns in the five study states.

The reduced form coefficients of the race and ethnicity variables in the infant mortality equations varied across the study states. In Florida, the mortality rate for infants of black Medicaid mothers was significantly higher than the mortality rate for infants of white Medicaid mothers (the omitted category); in Minnesota, North Carolina, and South Carolina, the mortality rate for infants of white and black Medicaid mothers were roughly the same; and in Texas, the 6-month mortality rate for infants of black mothers was significantly less than the mortality rate for infants of white Medicaid mothers.

In contrast to their differential effects on infant mortality across the study states, race and ethnicity had remarkably similar impacts on the probability of low birthweight across the study states. In all five states, newborns born to black Medicaid mothers were significantly more likely to be low birthweight than newborns born to white Medicaid mothers. In Florida and Texas, newborns of Hispanic mothers were less likely to be low birthweight than newborns of white mothers, and in Minnesota, newborns of Native American Medicaid mothers were also less likely to be low birthweight than newborns of white Medicaid mothers.

Structural Coefficients. The structural coefficients for the infant mortality equations are presented in Table B.4. In principle, the structural coefficients enable us to determine whether the total (reduced-form) effects of WIC participation on infant mortality reflect only an indirect effect operating through reductions in the likelihood of low birthweight or whether there is an additional direct effect of prenatal WIC participation on infant mortality. The principal findings from the structural model estimates are the following:

- With the exception of Texas, the structural parameter estimates for prenatal WIC participation, which measure the direct effect of WIC, are not significantly different from zero.

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TABLE B.4

STRUCTURAL EQUATION ESTIMATES OF A MODEL OF INFANT MORTALITY AMONG MEDICAID NEWBORNS
(Standard Errors in Parentheses)

Explanatory Variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	-2.423 **	-1.252 **	-1.517 **	-.383	-2.441 **
	(.471)	(.364)	(.322)	(.694)	(.456)
Prenatal WIC Participation by 30 Weeks Gestation	-.118	.001	-.105	-.279	-.168 *
	(.074)	(.073)	(.066)	(.166)	(.070)
Low Birthweight	.113	.667 **	.524 *	1.190 *	-.094
	(.340)	(.235)	(.232)	(.569)	(.351)
Male Newborn	.234 **	.029	.107 *	.268 **	.058
	(.062)	(.075)	(.049)	(.090)	(.057)
Multiple Birth	.437	-.773	-.301	-1.318	.818
	(.576)	(.427)	(.396)	(.954)	(.571)
Black[a]	.246 *	-.049	-.046	-.306 *	-.170 *
	(.101)	(.136)	(.061)	(.145)	(.072)
Hispanic[a]	.163	--	--	--	-.151 *
	(.090)				(.077)
Native American	--	.113	--	--	-.151 *
		(.147)			(.077)
Asian	--	-.134	--	--	--
		(.163)			
Other race/ethnicity[a]	--	--	--	--	-.221
					(.176)
Kessner Index inadequate	.224	.019	.126	-.236	.172
	(.138)	(.152)	(.118)	(.204)	(.112)
Kessner Index intermediate	.038	-.023	.0002	-.071	.003
	(.052)	(.087)	(.078)	(.084)	(.063)
Kessner Index unknown	.292 *	-.017	.026	-.549	.336
	(.135)	(.124)	(.165)	(.320)	(.116)
Urban	-.082	-.011	.009	-.082	--
	(.067)	(.075)	(.047)	(.072)	
Prenatal care from public health clinic	-.057	--	--	--	--
	(.080)				
Sample Size	31,732	11,547	20,687	11,773	25,710

SOURCE: WIC-Medicaid newborn database.

NOTE: The dependent variable is equal to one if the Medicaid newborn died within one year after birth, and equal to zero otherwise. In Texas, the dependent variable is equal to one if the Medicaid newborn died within six months after birth, and equal to zero otherwise.

*(**): Significant at the .05 (.01) level, two-tailed test.

--: Variable not on the state database.

[a]Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, nonspanish," "Hispanic" means "Mexican," and "Other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."

- For Florida, North Carolina, and South Carolina, the structural coefficients of prenatal WIC participation are not statistically significant, while the reduced-form coefficients are statistically significant. In other words, although the total effects of prenatal WIC participation are statistically significant, the direct effects are not.

- In Minnesota, North Carolina, and South Carolina, whether the newborn is low birthweight is one of at most two or three significant predictors of infant mortality. However, in Florida and Texas, low birthweight is ***not*** a significant predictor of infant mortality, which is very surprising. In Texas, low birthweight has a small (but not statistically significant) ***negative*** effect on infant mortality, implying the implausible result that low birthweight babies have lower infant mortality.

Table B.5 provides additional information on the total, direct, and indirect effects of prenatal WIC participation. In this table, the coefficients from both the reduced form and structural equations have been used to calculate predicted infant mortality rates with and without prenatal WIC participation. Using the reduced form infant mortality equation, the difference in the predicted infant mortality rates with and without WIC give an estimate of the total effect of prenatal WIC participation. Using the structural infant mortality equation, the difference in the predicted infant mortality rates with and without WIC give an estimate of the direct effect of prenatal WIC participation. Our principal findings are:

- ***The total effects of WIC participation on infant mortality are very large.*** Although the reduction in infant mortality associated with WIC participation is 9 percent for Minnesota, the reduction in infant mortality is at least 30 percent in each of the other four states, reaching as high as 76 percent for South Carolina.

- ***Relative to the total effects, the direct effects of WIC participation on infant mortality are large from a substantive point of view.*** Except for Minnesota where we estimate a small (and negative but not significant) direct effect, the direct effect is more than half the total effect in each state. Such direct effects seem implausibly large. Because the main WIC benefit is food

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TABLE B.5

TOTAL, DIRECT, AND INDIRECT EFFECTS OF PRENATAL WIC PARTICIPATION ON INFANT MORTALITY

	Florida	Minnesota	North Carolina	South Carolina	Texas
Total Effects of WIC					
Infant mortality rate with WIC	8.2	12.5	12.9	8.8	7.1
Infant mortality rate without WIC	11.7	13.8	21.3	36.0	11.0
Difference	-3.5 **	-1.3	-8.4 **	-27.2 **	-3.9 **
Direct Effect of WIC					
Infant mortality rate with WIC	8.7	14.8	16.8	19.1	7.0
Infant mortality rate without WIC	11.8	14.8	21.6	36.0	11.0
Difference	-3.1	0.0	-4.8	-16.9	-4.0 *
Direct Effect as a Proportion of the Total Effect of WIC	.89	--	.57	.62	1.03
Indirect Effect as a Proportion of the Total Effect of WIC	.11	--	.43	.38	-.03

SOURCE: WIC-Medicaid newborn database.

NOTE: The infant mortality rates are the predicted number of infant deaths per 1,000 live births and are based on the reduced form and structural parameter estimates presented in Tables 4-6.

*(**): Significant at the .05 (.01) level, two-tailed test.

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supplementation, we expect WIC participation to lower infant mortality mainly indirectly by raising birthweight.

The main conclusion to draw from Tables B.4 and B.5 is that the direct effects of WIC participation on infant mortality cannot be estimated precisely with available data. Even though the estimated direct effects seem large for four of the five states (Table B.5), only the direct effect for Texas can be statistically differentiated from zero (Table B.4). The problem is that the observed variables that most strongly influence the likelihood of low birthweight also strongly influence the likelihood of an infant death, and, thus, we are unable to separate the effects of the explanatory variables on low birthweight from their effects on infant morality. This explains the large standard errors in the infant mortality equation, resulting in the insignificant direct effects of WIC participation on infant mortality, the insignificant effects of low birthweight in Florida and Texas, and the insignificant direct effects of the adequacy of prenatal care in all the study states. To identify more precisely the structural determinants of infant mortality and to separate the direct from indirect effects, we would need variables that are strong determinants of birthweight but have only *indirect* effects on infant mortality operating through birthweight. As it turns out, such variables are either not available or not available in the WIC-Medicaid database.